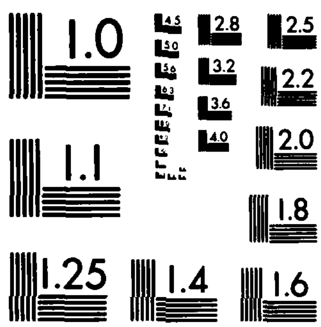
AD-A145 126 FLIGHT DEMONSTRATION OF NEW NRL REAL-TIME DATA ACQUISITION SYSTEM AND LASER VIDEO WAVEFORM SAMPLER(U) NAVAL RESEARCH LAB WASHINGTON DC C S LIN ET AL. 1/1

UNCLASSIFIED 03 SEP 84 NRL-MR-5396 F/G 9/2 NL

END



MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

(2)

NRL Memorandum Report 5396

Flight Demonstration of New NRL Real-Time Data Acquisition System and Laser Video Waveform Sampler

C. S. LIN,* E. A. ULIANA, AND D. L. HAMMOND**

Space Sensing Applications Branch
Aerospace Systems Division

**Naval Ocean Research and Development Activity*
NSTL, MS 39529

***Office of Export Administration*
Department of Commerce
Washington, DC 20230

September 3, 1984

NAVAL RESEARCH LABORATORY
Washington, D.C.

SECURITY CLASSIFICATION OF THIS PAGE

REPORT DOCUMENTATION PAGE

1a REPORT SECURITY CLASSIFICATION: UNCLASSIFIED

1b RESTRICTIVE MARKINGS:

2a SECURITY CLASSIFICATION AUTHORITY:

2b DECLASSIFICATION / DOWNGRADING SCHEDULE:

3 DISTRIBUTION / AVAILABILITY OF REPORT: Approved for public release; distribution unlimited.

4 PERFORMING ORGANIZATION REPORT NUMBER(S): NRL Memorandum Report 5396

5 MONITORING ORGANIZATION REPORT NUMBER(S):

6a NAME OF PERFORMING ORGANIZATION: Naval Research Laboratory

6b OFFICE SYMBOL (If applicable): Code 7912

7a. NAME OF MONITORING ORGANIZATION:

6c. ADDRESS (City, State, and ZIP Code): Washington, DC 20375

7b. ADDRESS (City, State, and ZIP Code):

8a. NAME OF FUNDING / SPONSORING ORGANIZATION: NAVAIR and ONR

8b OFFICE SYMBOL (If applicable):

9. PROCUREMENT INSTRUMENT IDENTIFICATION NUMBER:

8c. ADDRESS (City, State, and ZIP Code): Washington, DC 20361 Arlington, VA 22217

10 SOURCE OF FUNDING NUMBERS

PROGRAM ELEMENT NO.	PROJECT NO.	TASK NO.	WORK UNIT ACCESSION NO.
(See page ii)			

11 TITLE (Include Security Classification): Flight Demonstration of New NRL Real-Time Data Acquisition System and Laser Video Waveform Sampler

12 PERSONAL AUTHOR(S): Lin, C.S.,* Uliana, E.A., and Hammond, D.L.**

13a. TYPE OF REPORT: Interim

13b. TIME COVERED: FROM ________ TO ________

14 DATE OF REPORT (Year, Month, Day): 1984 September 3

15. PAGE COUNT: 17

16 SUPPLEMENTARY NOTATION: *Naval Ocean Research and Development Activity, NSTL, MS 39529
**Office of Export Administration, Department of Commerce, Washington, DC 20230

17 COSATI CODES

FIELD	GROUP	SUB-GROUP

18 SUBJECT TERMS (Continue on reverse if necessary and identify by block number):
Real-time data acquisition system
Laser waveform sampler

19 ABSTRACT (Continue on reverse if necessary and identify by block number)

A new NRL Laser Video Waveform Sampler and Real-Time Data Acquisition System were installed in a RP-3A aircraft and data were obtained in a test flight over the Great Dismal Swamp area on 28 June 1982. The data are in time amplitude pairs, which give both range and reflectivity, and are stored on magnetic tape. The returns show reflections from various levels of the canopy. The results show that it is possible to profile a complicated terrain in order to determine the vegetation and undergrowth height and the relative reflectivities of the various surface.

20 DISTRIBUTION / AVAILABILITY OF ABSTRACT: ☒ UNCLASSIFIED/UNLIMITED ☐ SAME AS RPT ☐ DTIC USERS

21 ABSTRACT SECURITY CLASSIFICATION: UNCLASSIFIED

22a NAME OF RESPONSIBLE INDIVIDUAL: E. A. Uliana

22b TELEPHONE (Include Area Code): (202) 767-3443

22c. OFFICE SYMBOL: Code 7912

DD FORM 1473, 84 MAR — 83 APR edition may be used until exhausted. All other editions are obsolete.

SECURITY CLASSIFICATION OF THIS PAGE

10. SOURCE OF FUNDING NUMBERS

PROGRAM ELEMENT NO.	PROJECT NO.	WORK UNIT ACCESSION NO.
62759N	WF59-553	DN091-002
61153N	RR032-08-41	DN220-038

CONTENTS

FLIGHT DEMONSTRATION OF NEW NRL REAL-TIME DATA ACQUISITION SYSTEM AND LASER VIDEO WAVEFORM SAMPLER

1.0 INTRODUCTION

A new real-time data acquisition system has been designed at the Naval Research Laboratory (NRL) in Washington, D. C. to support active and passive airborne experiments performed by the Space Sensing Applications Branch, Space Systems and Technology Division. The new system uses a PDP 11/34A computer as the host processor, and various interface controllers and circuits are added according to the individual requirements of each sensor system used in the particular experiment.

A flight demonstration of the capabilities of the new data acquisition system, interfaced to the NRL laser video waveform sampler system, was performed on 28 June 1982 over the Great Dismal Swamp located on the Virginia-North Carolina border. The various components used and preliminary experimental results are discussed in the following sections.

2.0 LASER VIDEO WAVEFORM SAMPLER SYSTEM

The sensor portion of the system is a solid state diode laser profilometer manufactured by Associated Controls and Communications, Inc. The laser wavelength is 904 nanometers with a pulse width of 10 nanoseconds, a beamwidth of 1.5 milliradians, and a peak power of 65 watts (Hammond 1982).

The video waveform sampler portion consists of a high-speed digitizer (Biomation 6500) and specially designed digital circuits to sample, store, and output the digitized laser video signal waveforms and the laser flight time.

The nadir-looking laser is mounted in the fairing of the NRL RP-3A. At the normal aircraft operating altitude of 500 feet, the laser footprint is approximately 0.75 foot (or 23 centimeters).

3.0 COMPUTERS AND INTERFACES

3.1 Computers

The host processor for the new data acquisition system is a PDP 11/34A computer with a 256 Kilobyte memory, two 1600 bpi tape drives, and two DEC-RL01 disk drives. The 1600 bpi tape drive has a throughput rate of 36,000 words per second, while the DEC-RL01 disk drive data transfer rate is 250,000 words per second.

Manuscript approved April 27, 1984.

The total storage capacity of a 2400-foot digital magnetic tape recorded at 1600 bpi is about 46 megabytes, while the total RL01 disk storage capacity is 5.2 magabytes.

A LA-120 typewriter terminal is used as the system console, which provides a permanent record of system activities during the airborne tests.

During the June 1982 test flight, only one of the two tape drives was flown in the aircraft because of space and weight constraints. The computer was operated for more than 40 flight-hours without a single failure. Both the disk and tape drives functioned correctly even during rough flight conditions.

3.2 Computer Interface

The laser video waveform sampler system was supported by this new data acquisition system during the 28 June 1982 test flight. The laser, which has a 125 KHz maximum data output rate, uses a DR11-B interface board mounted on the PDP 11/34A backplane to transfer the laser data output into the computer memory. With a data throughput rate of 512 KHz, the DR-11B interface board data rate is comparable to the highest data burst rate of the laser video waveform sampler system. A small peripheral slot on the PDP 11/34A was modified for the DR11-B, which is a direct memory access interface board. A simple electronic interface circuit was designed to handle the handshake between the DR11-B and the output of the laser video sampler. A schematic diagram of the interface circuit is shown in Figure 1, and the signals and voltages applied to the two 40-pin berg connectors on the DR-11B are shown in Table 1.

This interface circuit is mounted on a vector board which is mounted in a 8 x 3.5-inch mini box. There are also two 40-pin berg connectors and one RS232 connector mounted on the mini box. The berg connectors are connected to the DR11-B board with two 40-pin ribbon cables while the RS232 is connected to the laser video waveform sampler with a 25-wire cable.

4.0 SOFTWARE CONTROL OF THE DR11-B INTERFACE

Data acquisition is controlled by software stored in the PDP-11. It manipulates the DR11-B interface through four registers: vector, count, bus address, and command status whose addresses are 124, 172410, 172412, and 172414, respectively. The software must perform the following functions:

(a) The computer, the word count register, and the bus address are loaded with proper values to initiate data transfer between the laser sampler and the computer.

(b) The go bit and interrupt enable bit are then set which sends a device command pulse to the laser video sampler interface circuit.

(c) When the laser video sampler output data is ready, a cycle request pulse is sent to the DR11-B interface board to initiate a data transfer into the computer memory.

TABLE 1: DR11-B Signal and Voltage

Connector P1			Connector P2	
Pin	Signal	RS232	Pin	Signal
1	DATI 15	(16)		NC
2	DATI 00	(1)	1	NC
3	DATI 14	(15)	2	NC
4	DATI 01	(2)	3	NC
5	DATI 13	(14)	4	NC
6	DATI 02	(3)	5	NC
7	DATI 12	(13)	6	NC
8	DATI 03	(4)	7	NC
9	DATI 11	(12)	8	NC
10	DATI 04	(5)	9	NC
11	DATI 10	(11)	10	NC
12	DATI 05	(6)	11	NC
13	DATI 09	(10)	12	NC
14	DATI 06	(7)	13	NC
15	DATI 08	(9)	14	NC
16	DATI 06	(8)	15	NC
17	Control In OV		16	NC
18	A00in OV		17	NC
19	ATTEN OV		18	NC
20	NC		19	NC
21	BA INC EN 5V		20	WC INC ENB 5V
22	NC		21	NC
23	NC		22	NC
24	NC		23	NC
25	NC		24	NC
26			25	NC
27	C 1 CONTROL IN 5V		26	NC
28	NC		27	NO LOCK OV
29	NC		28	NC
30	NC		29	NC
31	NC		30	NC
32			31	NC
33	SINGLE CYCL OV		32	NC
34			33	NC
35	NC		34	NC
36	NC		35	NC
37	NC		36	CYCLE REQUEST B (Device Flag)(PR3)
38	NC		37	NC
39	CYCLE REQUEST A (Device Flag) (PN23)		38	NC
40	NC		39	NC
			40	NC

(d) When the data transfer is completed, an end cycle pulse is sent to the laser video sampler to request more data. This process continues until the number of data samples transferred is equal to the word count requested.

(e) An interrupt service routine is entered upon the word count overflow which resets the bus address and word count register to the previous value upon exit, and the laser data in the computer memory is then transferred to magnetic tape.

(f) After completion of the transfer, the go bit and interrupt enable bit are set and the previously described sequences will continue until the experiment is completed or the computer program is halted.

5.0 DATA STRUCTURE

The output of the laser video sampler interface are collected and packed into 512-byte data buffers. The data are arranged into time and amplitude pairs. The time indicates the delay after the laser pulse was transmitted to when it was received; the amplitudes are the digitized returned laser video pulses. Different legs of data are collected and put onto a 1600-bpi tape. Each leg of data is separated by an end-of-file mark. To convert the collected data into physical units, an offset of 780 nsec should be added to the time value on the tape. This offset value was preset at experiment time.

6.0 PRELIMINARY EXPERIMENTAL RESULTS

Data from the June 1982 flight demonstration have been reduced and data for Legs 3, 4, and 5 are plotted here in three different formats: (a) laser pulse flight time vs. experiment time, (b) laser return pulse amplitude vs. experiment time, and (c) the laser return pulse amplitude vs. laser pulse flight time. In format (a) an offset of 780 nsec has been added to the time of flight of the laser pulse in order to show the total laser pulse flight time, which reflects the aircraft altitude. It should be noted that all the data shown here are raw data as no attempt has been made to remove the aircraft motion from the data shown in Figures 2 and 3.

The P-3 altitude during the Great Dismal Swamp demonstration was approximately 141 meters (0.3m/nsec * 940 nsec)/2) as shown in panel A, Figure 2. The maximum vegetation height was 18 meters as shown in the same figure. Panel B of the same figure shows the relative reflectivity of the terrain. Both Figures 2 and 3 show that the reflectivity over the lake is slightly higher than over the tree tops and terrain. There is an apparent decrease in reflectivity of the laser signal between 125 and 150 sec into the flight on Leg 4. Leg 5 also shows some marked decrease in laser pulse reflectivity over the same area.

The Panel C in Leg 4 shows some double laser pulse returns from the same laser transmitted pulse. The ratio of the amplitude of the two returned pulses is of the order of 2 to 1. The first returned pulse is from the tree tops and the second return is from the ground (or undergrowth). The relative amplitude of the pulses shows the differences in reflectivity of the various reflecting surfaces while the time interval between the

pulses shows the height difference between the two reflecting surfaces. By varying the A/D threshold on the Biomation 6500, smaller return pulses can be recorded, and more return pulses can be detected which will describe more detailed height profiles. Figure 4 shows three return pulses from one transmitted laser pulse which are separated by 20 nsec and 45 nsec, or 3 meters and 6.75 meters, respectively, in distance. If one uses the last return pulse as the terrain level, the other two pulses could represent two different canopies at 9.75 meters and 6.75 meters height.

Figure 5 shows a typical laser return pulse from Lake Drummond. Figure 6 shows a laser return from the lake one second later. The pulse in Figure 6 shows considerable stretching. The stretching of the pulse indicates that there is spreading of the laser beam in the water caused by scattering from the particulate material in the water.

7.0 CONCLUSION

A flight demonstration performed over the Great Dismal Swamp on 28 June 1982 has shown that the fast direct memory access interface and A/D circuits enabled the PDP 11/34A computer based real-time data acquisition system to sample the waveform returns from the NRL laser video waveform sampler. The experimental results show that it is possible to profile a complicated terrain in order to determine the vegetation and undergrowth height. The amplitude of the return waveforms also reveal the relative reflectivities of the various reflecting surfaces.

The results over Lake Drummond are more complicated as shown in Figures 5 and 6. Figure 5 shows a normal gaussian shaped return waveform from the lake surface. In Figure 6, a complicated return waveform with substantial pulse stretching is observed. This kind of pulse stretching is caused by scattering of the laser beam in water, and is known to contribute to range biases in lidar applications.

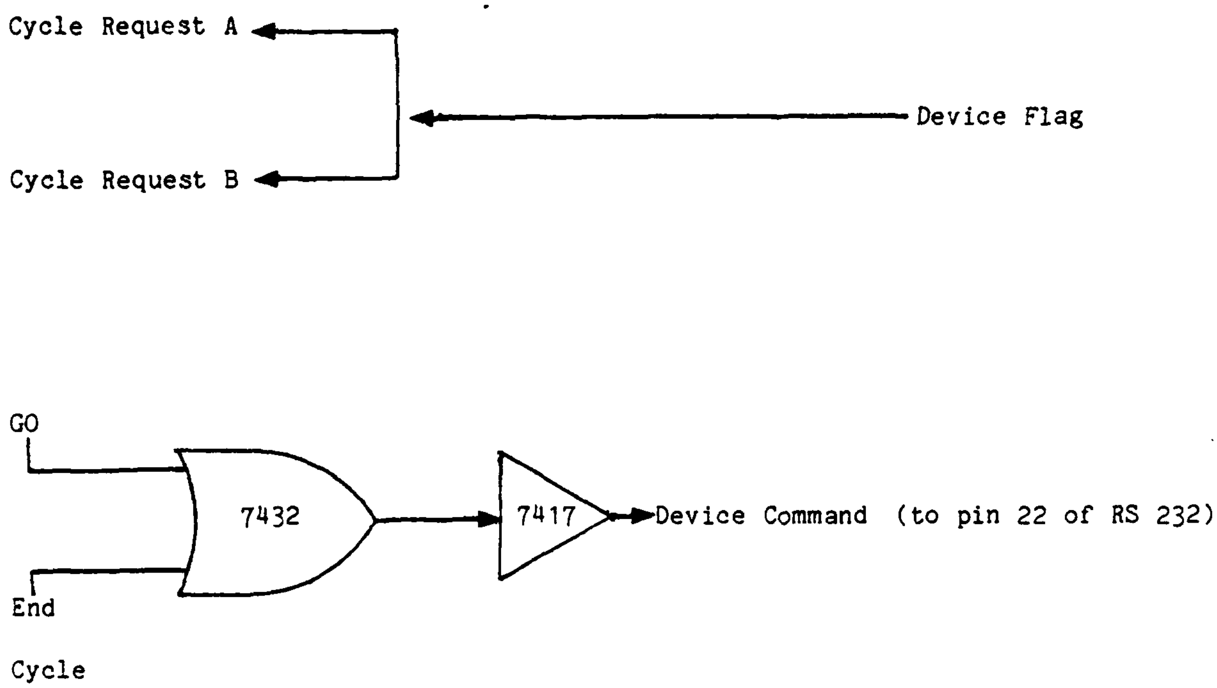


Fig. 1 — Schematic diagram of interface circuit between DR-11B and laser video sampler

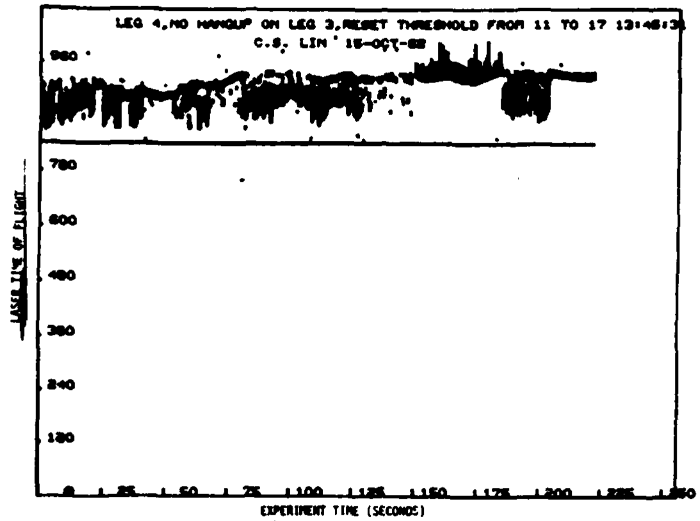


Figure 2A: Leg 4 Data

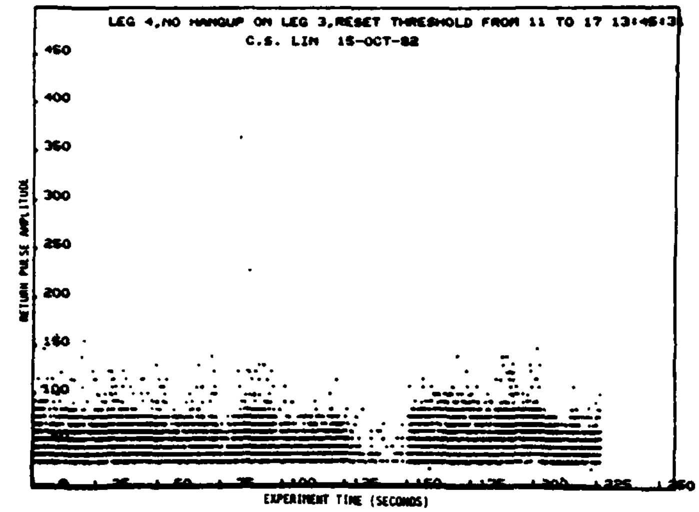


Figure 2B: Leg 4 Data

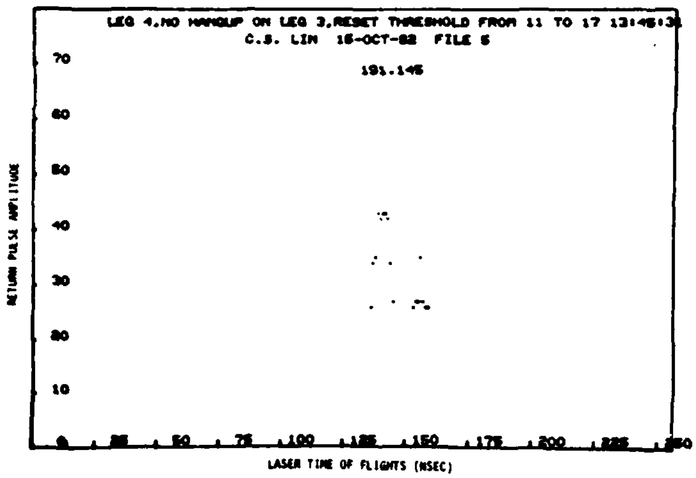


Figure 2C: Leg 4 Data

Fig. 2 — Laser data on June 28, 1982, Leg 4

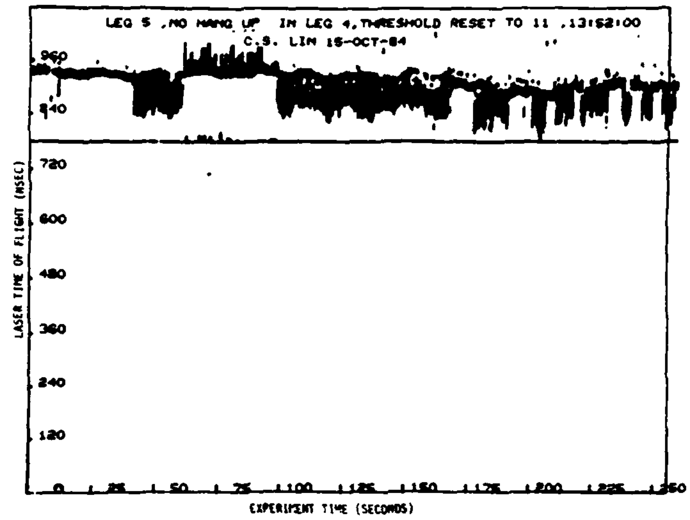


Figure 3A: Leg 5 Data

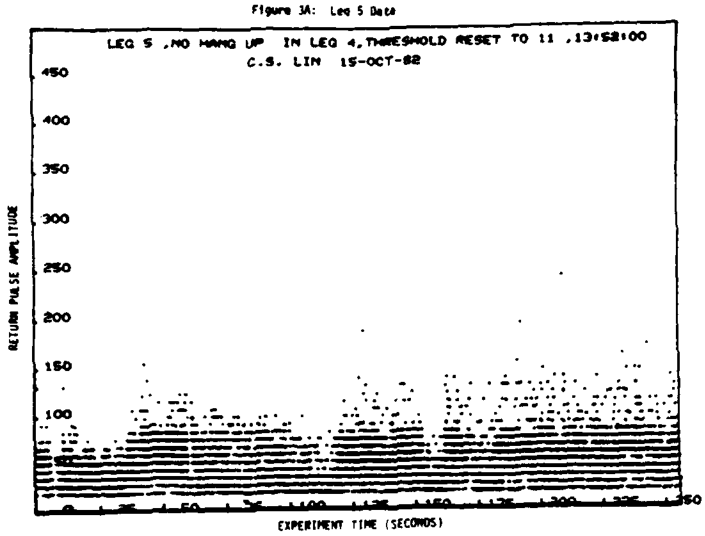


Figure 3B: Leg 5 Data

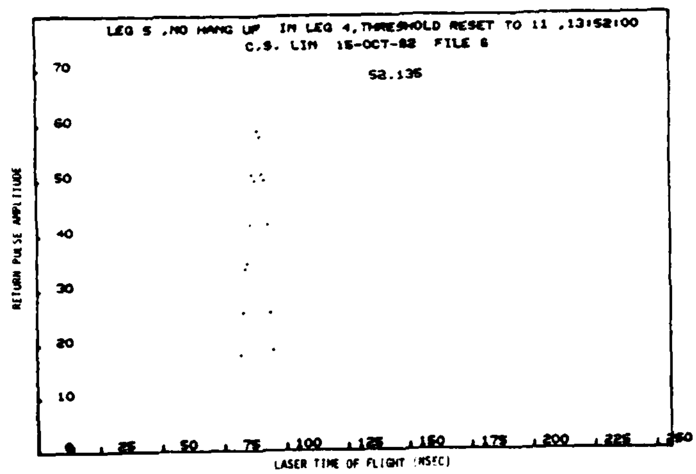


Figure 3C: Leg 5 Data

Fig. 3 — Laser data of June 28, 1982, Leg 5

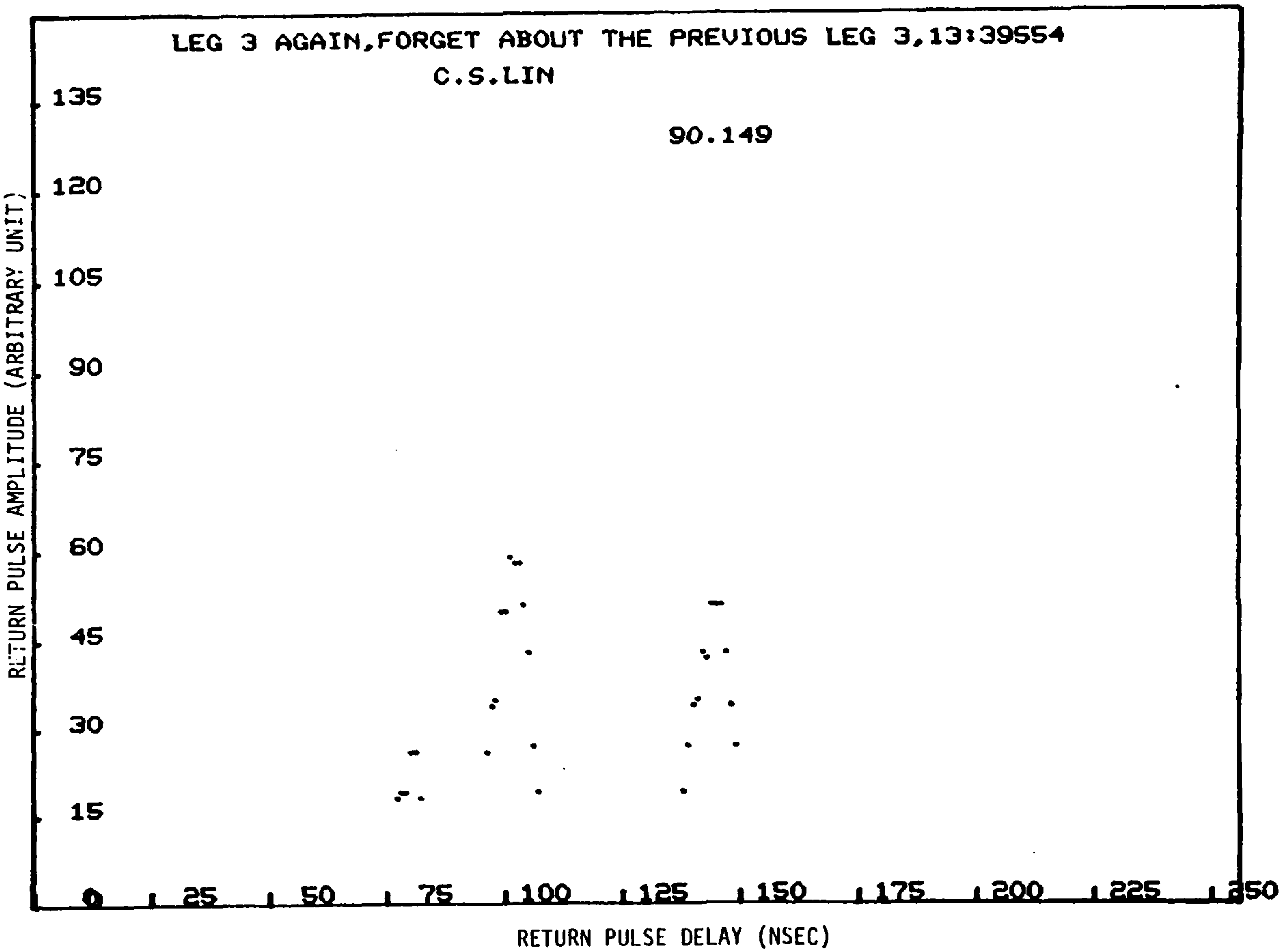


Fig. 4 — Laser return of single transmitted pulse over dense vegetation cover

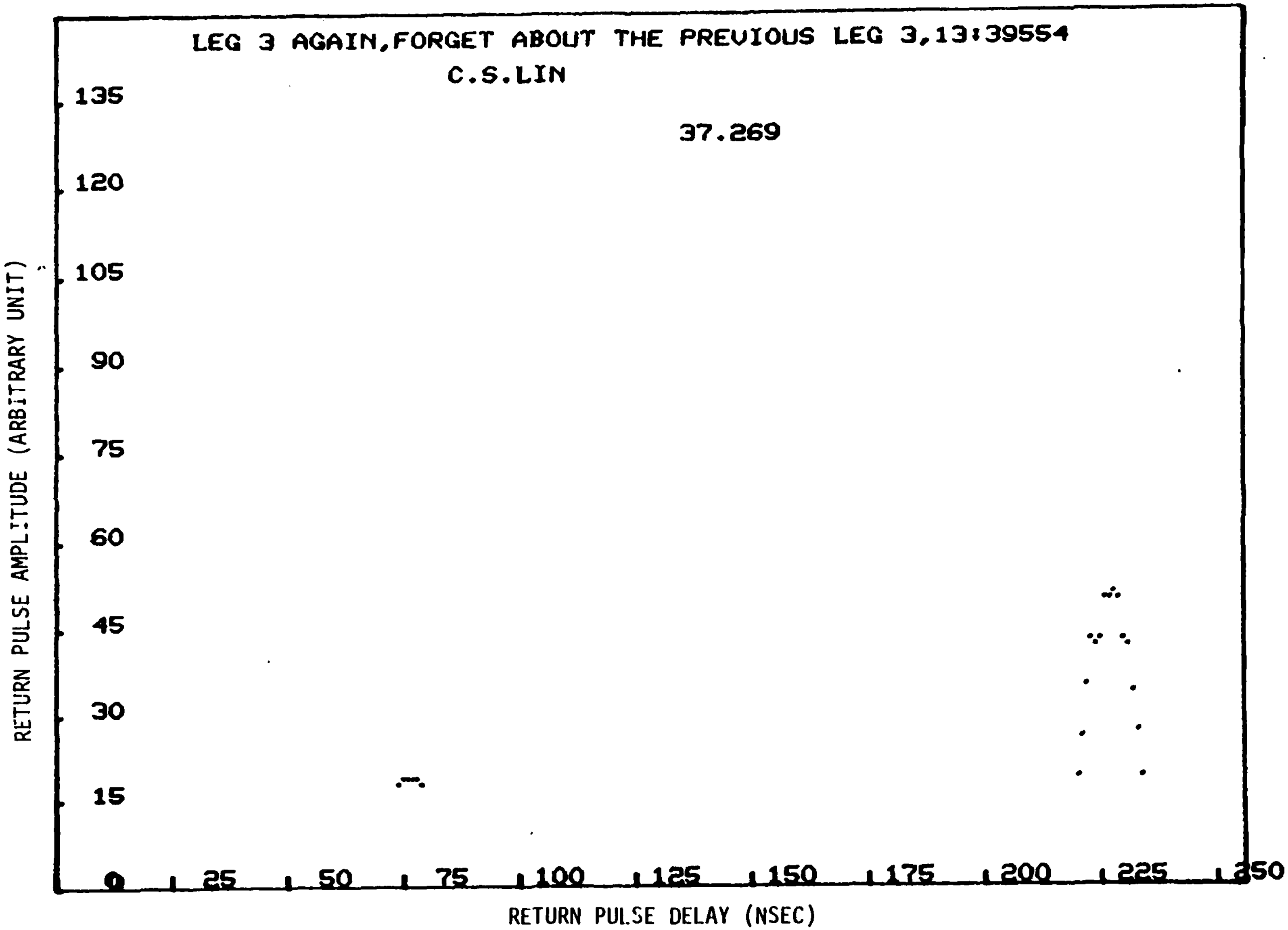


Fig. 5 — Typical laser return pulse from Lake Drummond

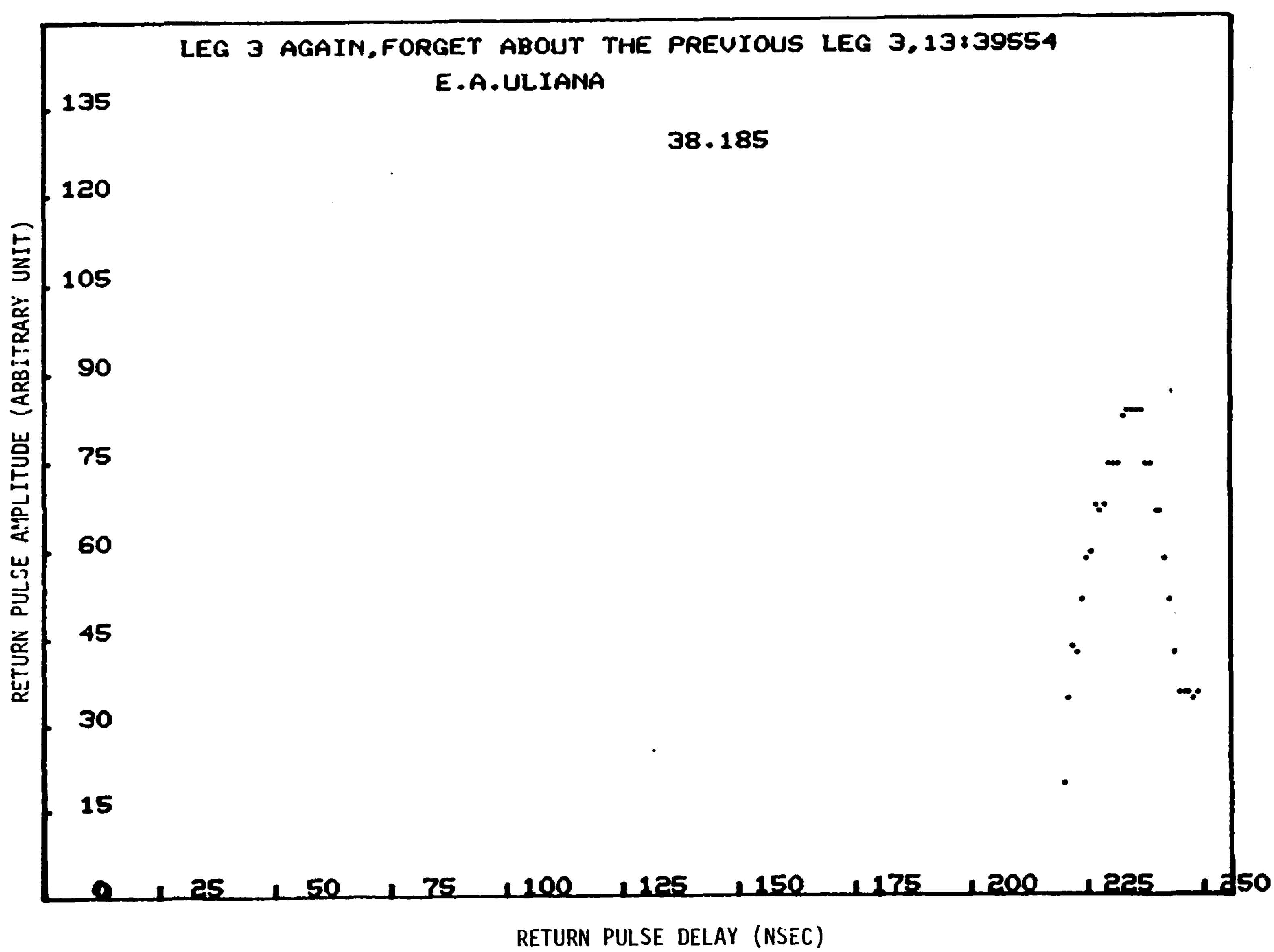


Fig. 6 — Stretched laser return pulse from Lake Drummond

ACKNOWLEDGMENTS

The data acquisition system was funded by the Naval Air Systems Command (AIR 333), Washington, DC 20361 via Naval Environmental Prediction Research Facility, Monterey, CA under Program Element 62759N, Project Number WF 59-553, "Environmental Remote Sensing", Technical Monitor, Dr. Alan I. Weinstein and by the Office of Naval Research, NRL NSF Program, Washington, DC 22217 under Program Element 61153N, Project Number RR0320841, "Environmental Remote Sensing".

The laser video waveform sampler was funded by U.S. Army Engineer Topographic Laboratory, Fort Belvoir, VA 22060, requisition 1521/E157/83, TASK 1352CC00010, Technical Monitor, Dr. Jack Rinker. Preliminary data analysis funded by Naval Electronic Systems Command (ELEX 190), Washington, DC 20363, under Program Element 3511N, TASK PME 106-48 058F 3X0922, "SENSOR ASSESSMENT STUDY", Technical Monitor CDR McConathy, PME 106-48, National Center #1, 2511 Jefferson Davis Highway, Arlington, VA 20360.

R. Wilkerson, now retired, designed and validated the performance of the laser video waveform sampler in the laboratory. A. Miller acted as general editor.

REFERENCES

Hammond, D. L. "RP-3A Flight Summary Report: Active Data Flights - June 1982," Informal NRL Report prepared 15 November 1982 in the Space Sensing Applications Branch, Aerospace Systems Division.

END

FILMED

10-84

DTIC